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Mobile applications (apps) for agriculture in Germany – a comparative market analysis

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Thanks to their multifunctionality, mobility and high data processing capacity, smartphones and their mobile applications have become a permanent companion for farmers in everyday life. This paper systematically analyses the mobile applications for agriculture available on the German market. The status quo (n = 1,214 apps) was recorded, systematically structured and descriptively evaluated based on the qualitative content analysis according to Mayring (2015). A comparison of these results with the study by Hoffmann et al. (2014) shows that the market offer for mobile apps is extremely dynamic. There are significantly more apps available for crop production (46.9 %; n = 569) than for livestock farming (28.6 %; n = 347). A vast majority (41.4 %; n = 503) is used to provide information. The app ratings suggest that the majority of users are satisfied with the mobile apps available for agriculture.

Keywords
Mobile applications, apps, agriculture, digitalisation, smartphone

The rapid technological developments of recent years, such as artificial intelligence, machine learning, robot technologies or the Internet of Things, have led to significant changes in agriculture. A farm manager needs early access to information on which he can base smart, success-oriented farm decisions. The availability of up-to-date, high-quality, meaningful data is the key to improved information provision and decision-making (Fountas et al. 2006, Magne et al. 2010, Fountas et al. 2015). Digital technologies, such as automatic milking systems in dairy farming, automatic feeding systems in livestock farming, the use of drones to detect and control pests and digital-based technologies for field mapping or site-specific management, provide a wide data range for improved decision-making and are being used more frequently on farms in Germany. In addition, digitalisation in the agricultural sector also includes the use of mobile end devices with the corresponding mobile applications (apps) (Doluschitz 2007, Paetowt 2017, Bundesministerium für Ernährung und Landwirtschaft 2018, Grabowsky et al. 2021).

The word „app" is an abbreviation of the English term „application software" and is used synonymously for the term „mobile application" (Bundesamt für Sicherheit in der Informationstechnik 2021). The application software is installed as an executable programme on a mobile end device and has a wide range of functions that can be expanded. Mobile applications can be categorised as native apps, web apps and hybrid apps. Native apps are specially developed for mobile devices and their pre-installed operating system and can be downloaded from the app store (Landesanstalt für Medien und Kommunikation Rheinland-Pfalz 2021). An operating system is pre-installed on every mobile end device. The Android operating system from Google LCC and the iOS operating system from Apple Inc. are the most commonly used for mobile devices. At the beginning of 2021, these two

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operating systems covered around 99.4 % of the global market. The Android operating system had a market share of 71.93 % and iOS of 27.47 % (Statcounter GlobalStats 2021).

Thanks to the established communication standard ISOBUS (ISO 11783) and the networking of agricultural machinery with mobile terminals, there has been ongoing expansion in the range of use and scope of application of mobile terminals in recent years. Apps often form the basis for the application of new or enhanced technologies that can help to increase yields (e.g. site-specific fertilisation), or optimise the use of inputs (e.g. quantity calculation and spatial distribution of the crop protection products to be applied). This not only supports farm optimisation but can also help to reduce the environmental impact of crop production (Horstmann 2018, Fröndhoff and Knitterscheidt 2019).

The purpose of this paper is to record the status quo in the market for mobile applications for agriculture in Germany, to categorise these applications systematically and to show market developments in recent years. The following research questions serve as a guideline:

1. How are the available mobile applications distributed among the agricultural production sectors?
2. Which functional areas are of particular importance in mobile applications for agriculture?

Methodical approach

To answer these research questions, a structured store search was conducted in the Google Play Store and the Apple App Store over the period from 10.05.2020 to 17.06.2020.

The scope of analysis includes all native apps that were available specifically for agriculture at the time of the search. The keywords „agriculture“, „agri“, „livestock farming“, „pig farming“, „cattle farming“, „poultry farming“, „crop production“, „arable land index“, „plant protection“ and „fertilising“ in German and English were used as search terms (cf. Table 1). The search results in the app stores and their contents may vary depending on the respective country version (Google Play Console 2021). This study is based exclusively on the German country version of the two app stores. In addition, only free app offers were recorded. Games, mobile applications of domestic horticulture as well as apps with a designation in Cyrillic, Chinese, Japanese or a comparable font were excluded from the data collection.

Table 1: Result and category matrix

Main category	Subcategory
Operating system/ platform	Android, iOS
Language	German, English, multilingual (German and English)
Keyword/ search term	Agriculture, agri, livestock farming, pig farming, cattle farming, poultry farming, crop production, arable land index, plant protection, fertilising
Production sector	Crop production, cattle farming, pig farming, poultry farming, mixed livestock farming, crop production & livestock farming, no assignment
Functional area	E-magazine, e-book, weather data, surveying & mapping, online shopping, navigation, remote control, arable land index, calculation, accounting, financial & market information, analysis, documentation, planning, information
Rating (stars)	1 to 1.9, 2 to 2.9, 3 to 3.9, 4 to 4.9, 5, no rating available

Source: Own representation, based on Hoffmann et al. (2014). Rating in stars: 1 star = worst rating; 5 stars = best rating.

During the study period, n = 1,214 different native mobile applications for agriculture were recorded and evaluated according to the qualitative content analysis by Mayring (2015) which consists of three distinct variants: summarising, explaining and structuring data material. Summarising and structuring were most important for this study. Targeted data (native mobile applications) was collected from the total material (total number of native mobile applications on the two store platforms) and systematically structured. This data material was subsequently evaluated in a targeted manner (Mayring 2015).

The systematic structuring and categorisation were carried out according to the six main categories listed in Table 1, each of which stands for itself: „Operating system/platform“, „Language“, „Keyword/search term“, „Production branch“, „Functional area“ and „Rating“ as well as the corresponding subcategories. Each result was assigned to a respective subcategory. Only in the main category „Functional area“ several answers were possible due to the various purposes of some apps. The main categories and subcategories were defined inductively from the data material using content reduction in accordance with the publication by Hoffmann et al. (2014). The main difference in Table 1 compared to the structure of the result matrix from the study by Hoffmann et al. (2014) is the replacement of the two main categories: „Provider type“ (e.g. retail or industry) and „Number of downloads“ with the two main categories „Keyword/ search term“ and „Rating“ in the present study (Table 1). Based on the frequency analysis, the data were summarised, evaluated according to the frequency they exhibit and compared with each other according to predefined criteria (Mayring 2015). The MS Office application Microsoft Excel was used for the categorisation and subsequent descriptive evaluation of the data. The contents were presented in a compact and clear form for the subsequent evaluation using a pivot table (Bradley and Joos 2020).

Results

Within the framework of this study, n = 1,214 native mobile applications (apps) directly related to agriculture were reviewed. The results show that the majority of the apps surveyed (62.3 %; n = 756), can be used via the Android operating system, 28.5 % (n = 346) can be used exclusively via the iOS operating system, while those apps that are suitable for both the Android and iOS operating systems have the lowest share (9.0 %; n = 109) in the sample. More than half of the mobile apps (52.9 %; n = 642) are in German and just under a third (31.0 %; n = 376) are in English. Multilingual offers in German or English hold the smallest share (16.1 %; n = 196).

It must be noted that apps used exclusively in the crop production sector hold a 46.9 % (n = 569) share. Figure 1 shows that 16.9 % (n = 205) of the mobile apps can be used in both livestock farming and crop production. A further 28.6 % (n = 347) can be used exclusively in livestock farming and thus either for mixed farms (crop production and livestock farming, n = 127), cattle farming (n = 91), poultry farming (n = 84) or pig farming (n = 45).

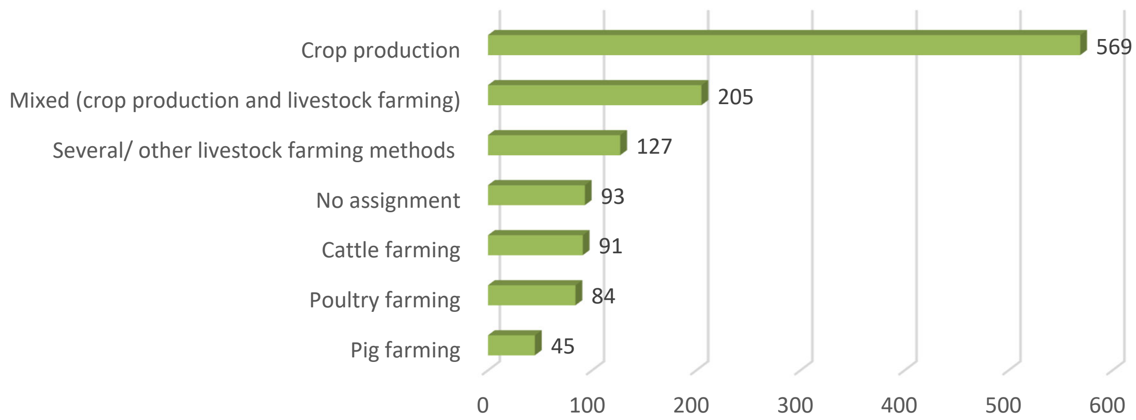

Figure 1: Number of native apps, structured according to agricultural production sectors (n = 1,214), source: own survey

The main purpose of 41.4 % (n = 503) of the apps is to provide information. These include, for example, apps for weed and pest detection (n = 46), for providing information on current weather data (n = 37), or apps that enable an exchange of information between users (n = 74). As Figure 2 shows, apps for documenting transactions (17.5 %; n = 212), or for analysis purposes (16.1 %; n = 195) are also frequently available for both the outdoor and indoor sectors of a farm. Mobile applications for the areas of „accounting", „surveying and mapping" and „navigation" play a subordinate role with a share of 5.4 % (n = 65).

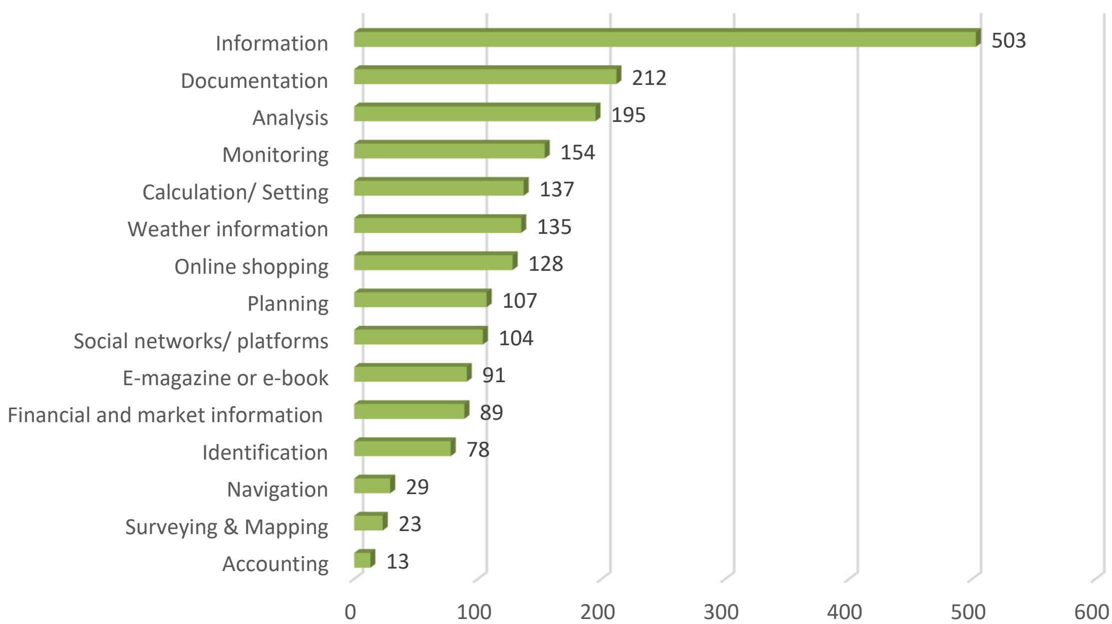

Figure 2: Number of native apps structured according to functional areas (n = 1,998; several answers possible), source: own survey

Overall, 35.7 % (n = 433) of the apps researched have no rating. On a scale of 1 star (worst rating) to 5 stars (best rating), over a third of the apps (39.3 %; n = 477) received 4 to 4.9 stars ($\overline{x}$ = 4.40; s = 0.26) which is a very good rating. 6.3 % (n = 77) merited the best rating with a full 5 stars. 15.5 % (n = 188) of the mobile applications fell within the range of 3 to 3.9 stars ($\overline{x}$ = 3.58; s = 0.28). 2.0 % (n = 25) of all apps received a rating of 2 to 2.9 stars ($\overline{x}$ = 2.55; p = 0.29) and 1.2 % (n = 14) obtained a rating between 1 and 1.9 stars ($\overline{x}$ = 1.18; p = 0.26).

Table 2: Star rating of apps by production sector, 2020 (n = 1,214), source: own survey

Production area	Mean value $\overline{x}$	Standard deviation s
Poultry farming	3.92	0.60
Cattle farming	4.06	0.54
No assignment	4.15	0.93
Crop production	4.16	0.66
Mixed livestock farming	4.19	0.69
Mixed crop and livestock production	4.20	0.78
Pig farming	4.26	0.79

Discussion

When these results are compared with those published by Hoffmann et al. (2014), it becomes clear that the availability of apps for agriculture in Germany has increased significantly in recent years. In 2014, there are a total of n = 521 apps available in the Google Play Store and the Apple App Store. In the following six years, this number has more than doubled (current study: n = 1,214) indicating that the market for mobile applications for agriculture has grown strongly and is also extremely dynamic. Given the increasing integration of mobile devices in agriculture over the years, this development is plausible and logically consistent. After all, the use of apps allows the range of functions of mobile end devices to be expanded to meet specific requirements (Landesanstalt für Medien und Kommunikation Rheinland-Pfalz 2021).

In 2012, mobile devices such as smartphones or tablets were used on more than 50 % of farms in Germany (Westerkamp et al. 2015). Six years later, a quantitative survey by Block et al. (2021) shows that of 161 farm managers surveyed in Germany, 90 % (n = 145) used a smartphone and 46 % (n = 74) a tablet for operational purposes. Therefore, it can be concluded that the range of mobile applications has expanded because the growing use of mobile end devices in agriculture has led to an increase in the demand for targeted service expansion through app installations. Furthermore, it can be seen that the majority of users are satisfied with the mobile applications that were analysed (cf. Table 2).

Two thirds of the apps (62.3 %; n = 756) can be used via the Android operating system. The proportion of apps that can be used exclusively via the iOS operating system is 28.5 % (n = 346). Only a few (9.0 %; n = 109) are suitable for both the Android and iOS operating systems. These market shares have changed since the study by Hoffmann et al. (2014) at which time around two thirds of the apps (66.4 %; n = 346) could be used via the Android operating system and 78.5 % (n = 409) via the iOS operating system and almost half (44.9 %; n = 234) could be used via both operating systems. The total number of apps available in 2020 in the two market-leading app stores (Google Play Store: 3.48 million; Apple App Store: 2.23 million) shows that the Android operating system has become the market leader in the intervening six years (cf. Rabe 2021). The shift in market share towards the Google LCC company, and thus towards the Android operating system, can be explained by the fact that the acquisition and use of Android devices cost less than Apple devices. In addition, the guidelines for uploading new apps are much stricter at Apple Inc. with its iOS operating system (cf. Apple Inc. 2022a). The company consistently checks new apps for faults and defects before an upload (WakeUp Media® GbR 2021, RedaktionsNetzwerk Deutschland GmbH 2020). In terms of revenue, Apple Inc. (2015: USD 28.6 billion; 2021: USD 85.1 billion) is the market leader. Despite its smaller market share, the company generates almost twice as much annual revenue from mobile apps as Google LCC in 2021 (2015: USD 15 billion; 2021: USD 47.9 billion) (cf. Rabe 2022). This higher turnover can be explained mainly by the higher willingness to pay exhibited by iOS users (Synium Software GmbH 2017). It is possible that users of mobile end devices from Apple Inc. (e. g. iPad, iPhone) feel they have an image to cultivate and are therefore willing to pay more for their mobile applications (Becker and Daschmann 2015). Furthermore, the iOS operating system offers a comprehensive security architecture consisting of hardware, software applications and services and this may be another reason for iOS users‘ higher willingness to pay for these mobile applications (Buck et al. 2017, Apple Inc. 2022b).

Apps for the crop production sector account for the largest share within this study (46.9 %; n = 569). Hoffmann et al. (2014), also identified that the majority of mobile applications (71.2 %; n = 371) were destined for this area. According to Roosen (2017), over the years, a lot of research and work has been devoted to the development and expansion of the digital infrastructure in the crop production sector and this could be a reason for the growing offer. The Roosen (2017) study concludes that farmers in Bavaria (n = 92) use apps principally in outdoor farming activities (40.2 %; n = 37) and a study by Bitkom Research shows that 40.0 % (n = 200) of respondents nationwide already actively use mobile applications in agriculture. A further 35.0 % have definite plans to adopt them (Rohleder et al. 2020). Compared to other digital technologies, such as farm management information systems, or site-specific application technology, mobile applications are characterised by their simple, almost intuitive handling, their low-cost or free acquisition and the direct visible benefit. These may be reasons behind the increased use of apps in outdoor farming (Busse et al. 2014, Husemann and Novković 2014, Roosen 2017, Gandorfer et al. 2017).

There is a wide range of mobile apps available for information provision (41.4 %; n = 503), for documentation (17.5 %; n = 212) and analysis (16.1 %; n = 195). This is probably linked to farmers' snowballing documentation requirements and the increased value of data for analysis and reporting purposes (Fountas et al. 2015, Deter 2020). The findings of Roosen (2017) and those of the 2020 Bitkom study (cited in Rohleder et al. 2020) indicate that mobile applications are increasingly being integrated into operational processes in foreign trade, at least in Germany. After all, the use of mobile applications can facilitate recurrent tasks and help farmers to make better informed decisions. Another possible reason is that farm processes can be monitored, documented and controlled more efficiently (Neumann 2018).

In livestock farming, apps can make an important contribution to improving animal health via automated feeding and generally enhancing animal welfare (Franken et al. 2019). Integration of mobile applications into everyday farm life can improve the farmer‘s own control measures and support him in his daily operational work (Proplanta GmbH & Co. KG 2021). The results of this present study show that there are now more apps available for livestock farming than there were at the time of the study by Hoffmann et al. (2014). In the current study, 28.6 % (n = 347) of the apps are used within pure livestock farming and 16.9 % (n = 205) on mixed farms (crop production and livestock farming). When compared with Hoffmann et al. (2014), this shows that between 2014 and 2020 the proportional increase in apps for livestock farming exceeds the increase in apps for crop production (current study 2020: +53.4 %; n = 198). Hoffmann et al. (2014), found that 17.9 % (n = 93) of the apps can be used on pure livestock farms (current 2020 study: +273.1 %; n = 254) and 10.9 % (n = 57) on mixed farms (current 2020 study: +259.6 %; n = 148). This development can be traced through the advancing digitalisation within livestock farming. Nowadays, automatic milking systems, automated slat cleaning and partially or fully automated feeding systems are becoming an integral part of livestock barns and, in most cases, their use and operation is supported by mobile applications (Deter 2016; Büscher 2018).

Conclusion

The results of the study presented in this article show that the range of mobile applications for agriculture in Germany has grown significantly in recent years. At the same time, the range of functions and services that an app can provide is becoming increasingly extensive.

There are far more mobile applications on offer for the crop production sector than for the livestock farming sectors analysed. It can be concluded that the market potential has not yet been fully exploited in the latter sector. In future, apps will provide even more support for farmers, especially in farm self-monitoring applied, for example, to automated feeding and the improvement of animal welfare.

The provision of information is of great importance to farmers. This is highlighted by the extensive range of apps in the functional areas of information, documentation and analysis. Mobile applications from the functional area of documentation can help to fulfil legal documentation requirements more easily or to comply with the increasing obligation to provide information to the authorities. Mobile applications can also contribute to facilitating recurrent work, to making more informed decisions and to helping the farmer optimise operational processes.

The dynamic market for mobile applications for agriculture shows the limitations of this study and consequently the present results only skim the surface. In particular, future studies should focus on developments in the supply of mobile applications for livestock farming (indoor farming). Trends and developments could then be identified at an early stage, interpreted in depth and appropriate utilisation recommendations set out for agricultural enterprises.

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